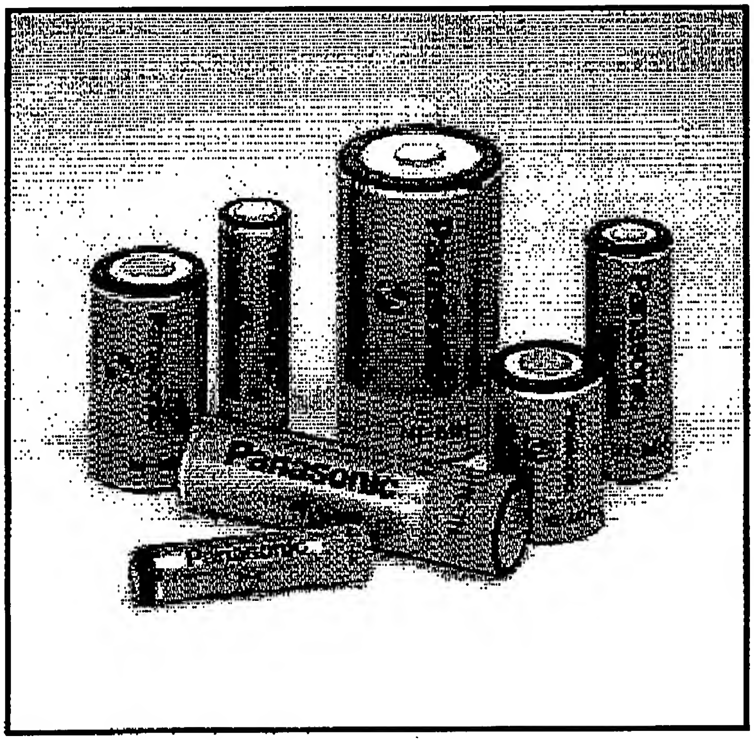
High-energy Batteries to Launch a New Era of Products



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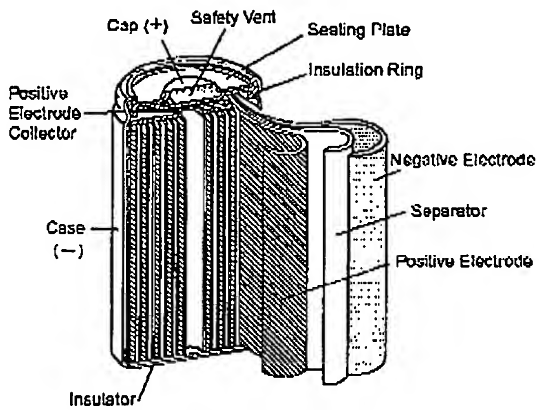
Overview

As electronic products have come to feature more sophisticated functions, more compact sizes and lighter weights, the sources of power that operate these products have been required to deliver increasingly higher levels of energy To meet this requirement, nickel-metal hydride batteries have been developed and manufactured with nickel hydroxide for the positive electrode and hydrogen-absorbing alloys, capable of absorbing and releasing hydrogen at high-density levels, for the negative electrode. Because Ni-MH batteries have about twice the energy density of Ni-Cd batteries and a similar operating voltage as that of Ni-Cd batteries, they have become a mainstay in rechargeable batteries.

Construction

Nickel-metal hydride batteries consist of a positive plate containing nickel hydroxide as its principal active material, a negative plate mainly composed of hydrogen-absorbing alloys, a separator made of fine fibers, an alkaline electrolyte, a metal case and a sealing plate provided with a self-resealing safety vent. Their basic structure is identical to that of Ni-Cd batteries. With cylindrical nickel-metal hydride batteries, the positive and negative plates are seperated by the separator, wound into a coil, inserted into the case, and sealed by the sealing plate through an electrically insulated gasket.

Structure of Nickel-Metal Hydride Batteries



Cylindrical Type

Hydrogen-absorbing Alloys

Hydrogen-absorbing alloys have a comparatively short history which dates back about 20 years to the discovery of NiFe, MgNi and $LaNi_5$ alloys. They are capable of absorbing hydrogen equivalent to about a thousand times of their own volume, generating metal hydrides and also of releasing the hydrogen that they absorbed. These hydrogen-absorbing alloys combine metal (A) whose hydrides generate heat exothermically with metal (B) whose hydrides generate heat endothermically to produce the suitable binding energy so that hydrogen can be absorbed and released at or around normal temperature and pressure levels. Depending on how metals A and B are combined, the alloys are classified into the following types: AB (TiFe, etc.), AB_2 ($ZnMn_2$, etc.), AB_5 ($LaNi_5$, etc.) and A_2B (Mg_2Ni, etc.). From the perspective of charge and discharge efficiency and durability, the field of candidate metals suited for use as electrodes in storage batteries is now being narrowed down to AB_5 type alloys in which rare-earth metals, especially metals in the lanthanum group, and nickel serve as the host metals; and to AB_2 type alloys in which the titanium and nickel serve as the host metals.

Panasonic is now focusing its attention on AB_5 type alloys which feature high capacity, excellent charge and discharge efficiency, and excellent cycle life. It has developed, and is now employing its own $MmNi_5$ alloy which uses Mm (misch metal = an alloy consisting of a mixture of rare-earth elements) for metal A.

Principle of Electrochemical Reaction Involved in Batteries

Nickel-metal hydride batteries employ nickel hydroxide for the positive electrode similar to Ni-Cd batteries. The hydrogen is stored in a hydrogen-absorbing alloy for the negative electrode, and an aqueous solution consisting mainly of potassium hydroxide for the electrolyte. Their charge and discharge reactions are shown below.

Positive electrode · $Ni(OH)_2 + OH^- \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} NiOOH + H_2O + e^-$

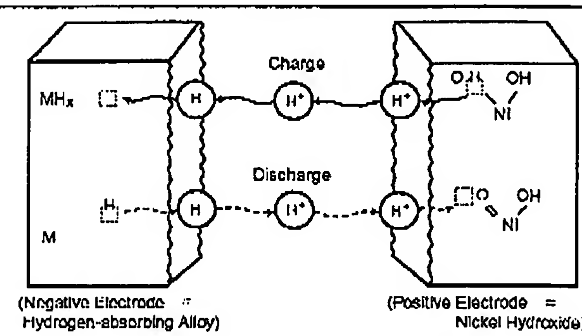
Negative electrode · $M + H_2O + e^- \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} MH_{ab} + OH^-$

Overall reaction · $Ni(OH)_2 + M \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} NiOOH + MH_{ab}$

(M· hydrogen-absorbing alloy· H_{ab}: absorbed hydrogen)

As can be seen by the overall reaction given above the chief characteristics of the principle behind a nickel-metal hydride battery is that hydrogen moves from the positive to negative electrode during charge and reverse during discharge, with the electrolyte taking no part in the reaction; which means that there is no accompanying increase or decrease in the electrolyte. A model of this battery's charge and discharge mechanism is shown in the figure below. These are the useful reactions taking place at the respective boundary faces of the positive and negative electrodes, and to assist one in understanding the principle, the figure shows how the reactions proceed by the transfer of protons (H^+).

The hydrogen-absorbing alloy negative electrode successfully reduces the gaseous oxygen given off from the positive electrode during overcharge by sufficiently increasing the capacity of the negative electrode which is the same method employed by Ni-Cd batteries. By keeping the battery's internal pressure constant in this manner, it is possible to seal the battery.



Schematic Discharge of Ni-MH Battery

GLOSSARY OF TERMS FOR NICKEL METAL HYDRIDE BATTERIES

Structural-related Items

- **Active Material**
  The electro-chemical materials of the electrodes. In rechargeable Ni-MH battery, nickel-hydroxide is the active material of the positive electrode and hydrogen-absorbing alloy is the active material of the negative electrode
- **Cell**
  Each of the individual batteries which comprise a rechargeable battery.
- **Electrolyte**
  The medium through which ions are conducted during the electro-chemical reaction inside a rechargeable battery. In rechargeable Ni-MH battery, a potassium hydroxide water solution is generally used as the electrolyte
- **Hydrogen-absorbing Alloy**
  Alloy which can absorb/release hydrogen reversibly. AB_5 or AB_2 type alloy is used for batteries ($MmNi_5$) AB_5 type is employed in Panasonic's products.
- **Negative Electrode**
  The electrode that has a lower electrical potential than the positive electrode to which electrical current flows from the external circuit during the discharge of a storage battery.
- **Nickel Oxyhydroxide**
  Expressed in chemical notation as NiOOH, this indicates that the positive electrode material of the Ni-MH battery is in a charged state. When in the discharged state, the positive electrode material becomes nickel hydroxide, or $Ni(OH)_2$.
- **Pasted Type Electrode Plate**
  An electrode plate made by applying the active material (hydrogen-absorbing compound) in a paste form onto a nickel-plated steel porous plate Used as the negative electrode.
- **Positive Electrode**
  The positive electrode that has a higher electrical potential than the negative electrode from which electrical current flows to the external circuit during the discharge of a rechargeable battery.
- **Safety Vent**
  Functions to release the gas when the internal pressure exceeds a predetermined level. In addition to preventing the absorption of external air into the rechargeable battery, this vent also prevents the rupture of the rechargeable battery that would result from the increase in the internal pressure caused by the generation of gas during charge or at other times.
- **Separator**
  A porous or micro-porous thin plate, cloth, bar, or frame which is inserted as a spacer between the positive and negative electrode plates for the purpose of preventing short-circuits. The separator must be non-oxidizing, resistant to chemicals, and be an electrical insulator, and it must not obstruct in any way the ionic conduction or diffusion of the electrolyte.
  The separator also functions to retain the electrolyte.